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PRODUCTION AND MECHANICAL PROPERTIES OF Al2618-TiC COMPOSITES

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ABSTRACT

This paper deals with the production and evaluation of mechanical properties by introducing micro size TiC particulates into Al2618 alloy matrix. TiC particle reinforced Al alloy metal matrix composites were prepared by stir casting method. Al2618 alloy was taken as the base matrix to which TiC particulates were used as reinforcements. 3 and 6 wt. % of TiC particulates were added to the base matrix. For each composite, the reinforcement particles were pre-heated to a temperature of 600 degree Celsius and then dispersed in steps of two into the vortex of molten Al2618 alloy to improve wettability and distribution. The Micostructural study was done by using optical microscope, which revealed the uniform distribution of TiC particles in matrix alloy. Mechanical properties like hardness, ultimate tensile strength and yield strength were evaluated as per ASTM standards. Hardness, ultimate tensile strength and yield strength increased with increased wt. % of TiC particulates in the base matrix Al2618 alloy.

KEYWORDS: Al2618 Alloy, TiC Particulates, Stir casting, Hardness, Ultimate tensile strength, Yield strength

Aluminium metal matrix composites (AMMCs) are being used for variety of applications owing to their good hardness and high tensile strength at room and elevated temperatures. The main advantages of particulate reinforced aluminium composites over other materials are their cost advantage, formability, improved corrosion and seizure resistance [Sahin.Y 2003]. Hence these AMMCs are used as cylinder blocks, disc brakes, calipers, connecting rods and structures for space applications. The properties of AMMCs are mainly depending on micro structural parameters of the reinforcing materials such as size, shape, orientation and volume fraction.

Many researchers during the last three decades have generated tremendous interest to use aluminium and its alloys due to their properties such as light weight, low cost, excellent mechanical and tribological properties compared to those of their corresponding conventional alloy. Adding hard ceramic particles with aluminium alloys has shown tremendous improvement in the properties [Umanath.K 2013,Shorowordi.K 2003]. Metal matrix composite materials have been under development for more than 20 years. However, the initial emphasis was on continuous filament metal matrix composites (MMCs). They were first developed for applications in aerospace, followed by applications in other industries. The expansion into non-aerospace and non-military fields came about slowly as the price of MMC materials was coming down. This is mainly due to the development of new low-cost composites.

In recent years, discontinuous MMCs have been investigated. Recent interest in discontinuous MMCs has been rekindled. So many researchers have been worked on metal matrix composites; below literature survey is an overview to know the contribution of different researchers in the field of particulate reinforced metal matrix composites.

Baradeswaran et al. [5] investigated the mechanical and Tribological behaviour Al7075 reinforced with B_4C particle composites, which were produced through liquid stir casting method. K2TiF6 was used to overcome the wetting problem

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between B_4C and liquid aluminium metal. The prepared composite samples were tested under T6 heat treatment process. Mechanical and tribological properties were studied on the samples. Hardness of composites were increased compared to base alloy, wear rate was decreased for composites and coefficient of friction decreased with increased B_4C reinforcement

Sridhar Raja et al. [6] experimented by considering A356 matrix as base alloy, which was reinforced with boron carbide particle. The method adopted for processing was stir casting technique. The wear mechanism was studied on prepared composites using wear testing machine, during this test the parameters considered for wear test were load applied, weight percentage of boron carbide and sliding distance. The results obtained were such as wear rate in terms of weight loss per unit load and wear volume. Their result shown that composite with 9% reinforcement of boron carbide has shown high wear resistance. The results are found to be increasing with increasing load and decreasing with increasing weight percentage of boron carbide. The purpose of the present work is to produce high strength composites made of Al2618 alloy and TiC particulates. In the present work it has been decided to prepare, characterize & evaluate the mechanical properties such as hardness and tensile properties of Al2618 alloy reinforced with TiC particulates.

EXPERIMENTAL

Materials Used

In this study, Al2618 alloy with the theoretical density of 2.80 g/cm^3 is used as the matrix and TiC particles of 50-60 microns and density of 4.90 g/cm^3 are used as the reinforcement. The composites are fabricated by novel two stage stir casting method. The chemical composition of Al2618 alloy is shown in Table 1.

Table 1: Chemical composition of Al2618 alloy used

Element	Wt. Percentage
Magnesium	1.50
Silicon	0.20
Iron	1.15
Copper	2.50
Zinc	0.10
Titanium	0.10
Nickel	1.10
Zinc	0.10
Aluminium	Bal

Composites Preparation

Figure 1: Shows the stir casting set up

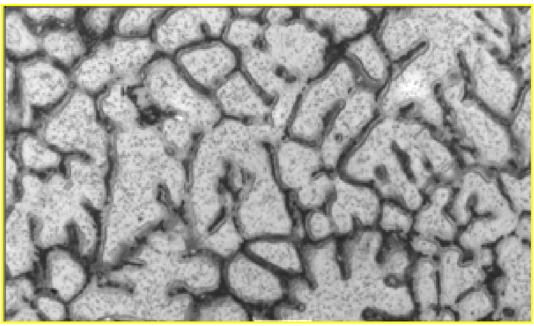
The composites were fabricated by stir casting method to ensure the uniform distribution of the TiC reinforcement in the Al2618 alloy matrix. The Al2618 alloy, which was in the form of ingot, was cut into small pieces to accommodate in the silicon carbide crucible. The TiC particulates for this study are procured from China. Al2618 alloy was first melted in an electric furnace at 730 degree Celsius. Titanium Carbide particulates 3 and 6 wt. % were preheated to a temperature of about 600 degree Celsius, were added to the molten metal at 730 degree Celsius and stirred continuously. The stirring was carried out at 300rpm for 5-8 min. Magnesium was added in small quantity during stirring to increase the wetting. The melt with TiC reinforcement was poured into a cast iron permanent mould. The stir casting set up used for the preparation of composites is shown in fig. 1.

Testing of specimens

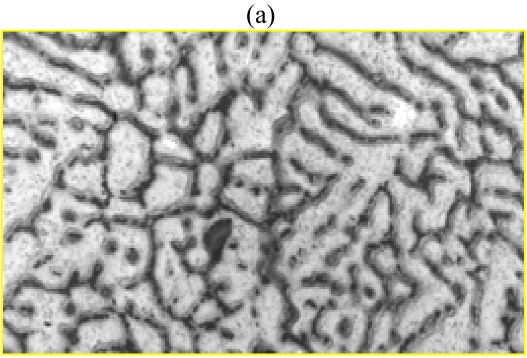
Microstructure and mechanical behavior of the Al2618 alloy and its composites were carried out. A metallographic examination was carried out by using optical microscope in Advanced Metallurgical Laboratory, Bangalore. The sample preparation for microstructural study was carried out first by polishing the sliced samples with emery paper up to 1000 grit size, followed by polishing with Al_2O_3 suspension on a grinding machine using velvet cloth. Finally, the samples were polished by using 0.3 microns diamond paste. The polished surface was etched with Keller's reagent and examined with a optical microscope. The tensile properties of the specimen were measured by using an electronic tensile testing machine at room temperature based on ASTM standard [Madeva Nagaral 2015]. Hardness tests were performed on as cast Al2618 alloy and Al2618-TiC composites to know the effect of TiC particles in the matrix material. The polished specimens were tested for their hardness, using Brinell hardness testing machine having ball indenter for 250 kg load and dwell time of 15 sec. Five sets of readings were taken at different places of the specimen and an average value was used for calculation.

RESULTS AND DISCUSSION

Microstructural Studies



(a)



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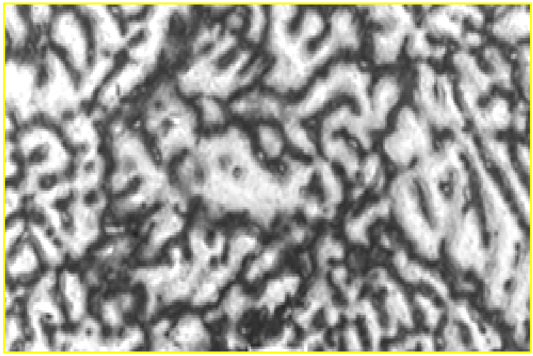

(c)

Figure 2: Showing the optical microphotographs of (a) as cast Al2618 alloy (b) Al2618-3wt. % TiC (c) Al2618-6 wt. % TiC composites at 500X

The optical micrographs of as cast Al2618 alloy and Al2618 alloy reinforced with 3 and 6 wt. % of TiC particulates are shown in fig.2 a, b and c respectively. Optical micrographs of Al2618 alloy composites revealed the uniform distribution of TiC particulates in the matrix, and no void and discontinuities were observed. Common casting defects such as porosity and shrinkages were not found in the micrographs. There was a good interfacial bonding between the TiC particles and Al2618 alloy matrix.

Hardness

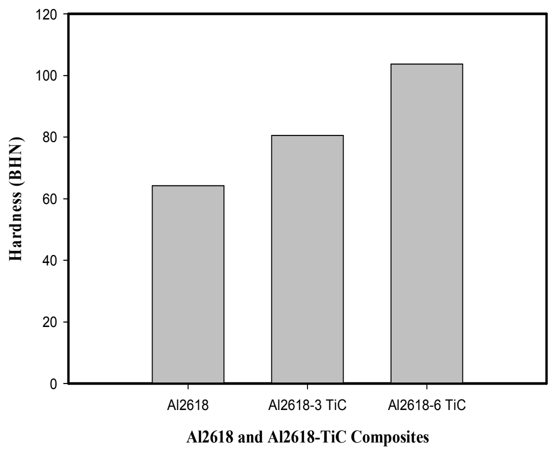

Figure 3: Showing the variation in hardness of as cast Al2618 alloy and its composites

The hardness values of the Al2618 alloy and Al2618-TiC composites have been obtained by Brinell hardness tester. The variation of hardness with Al alloy and its composite is shown in fig.3. It is noticed that the hardness of Al2618 - 3 and 6 wt. % TiC composites are more than Al2618 alloy. A notable rise in the hardness of the alloy matrix can be seen with the addition of TiC particles. This is mainly due to the presence of TiC particles in the matrix Al2618 alloy. Whenever a hard reinforcement is incorporated into a soft ductile matrix, the hardness of the matrix material is enhanced [Veereshkumar G 2012].

Ultimate Tensile Strength and yield strength

Fig. 4 shows the variation of ultimate tensile strength (UTS) Al2618 and with 3 & 6 wt. % of TiC particulates. The ultimate tensile strength of Al2618-3 & 6 wt. % of TiC composite material increases by an amount of 13.85% and 32.53 % as compared to as cast Al2618 alloy matrix. The microstructure and properties of hard ceramic TiC particulates control the mechanical properties of the composites. Due to the strong interface bonding load from the matrix transfers to the reinforcement exhibiting increased ultimate tensile strength.

This increase in UTS mainly is due to tic particles acting as barrier to dislocations in the microstructure [Auradi V 2014]. The improvement in UTS may be due to the matrix strengthening following a reduction in Al2618-TiC grain size, and the generation of a high dislocation density in the Al2618 alloy matrix.

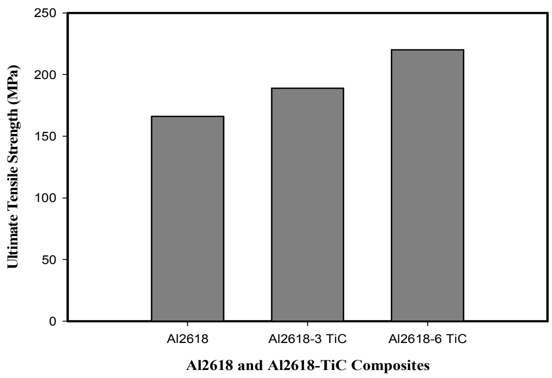

Figure 4: Showing the variation in ultimate tensile strength of as cast Al2618 alloy and its composites

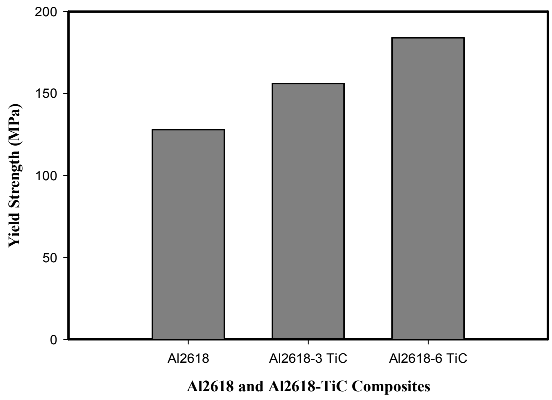

Figure 5: Showing the variation in yield strength of as cast Al2618 alloy and its composites

Fig. 5 shows variation of yield strength (YS) of Al2618 alloy matrix and with 3 & 6 wt. % of TiC particulate reinforced composites. It can be seen that by adding 3 & 6 wt. % of TiC particulates yield strength of the Al2618 alloy is increased from 128 MPa to 184 MPa. This increase in yield strength is in agreement with the results obtained by several researchers, who reported that the strength of the particle reinforced composites is more strongly dependent on the volume fraction of the reinforcement [ref]. The increase in YS of the composite is obviously due to presence of hard TiC particles which impart strength to the soft aluminium matrix resulting in greater resistance of the composite against the tensile stress. In the case of particle reinforced composites, there is a restriction to the plastic flow due to the dispersion of the hard particles in the matrix, thereby providing enhanced strength to the composite [Madeva Nagaral 2013].

CONCLUSIONS

The present work on production and mechanical behavior of Al2618-TiC metal matrix composites has led to following conclusions:

- Al2618-TiC particulate composites were successfully produced by liquid stir casting route with 3 and 6 weight percentage of TiC reinforcement.
- The optical microscopy photographs of composites produced by melt stirring method shows fairly uniform distribution of TiC particulates in the Al 2618 alloy metal matrix.
- Al2618-TiC composites have shown higher hardness when compared to the hardness of

Al2618 base alloy. Also hardness of composites increases with increasing wt. % of TiC reinforcement.

- Improvements in ultimate tensile strength of the Al2618 alloy matrix were obtained with the addition of TiC particulates. The extent of improvement obtained in Al2618 alloy after addition of 3and 6 wt. % of TiC particulates were 14 and 33 % respectively.
- Improvements in yield strength of the Al2618alloy matrix were obtained with the addition of TiC particulates. The yield strength of the Al2618 alloy is increased from 128 MPa to 184 MPa after adding 6 wt. % of TiC particulates.

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